DOCUMENT RESUME

ED 080 319 SE 016 263

AUTHOR Binns, Richard W.
TITLE Patterns of Enquiry: Textual Analysis of a Classroom Discussion Unit on Bee Feeding Behaviour.
INSTITUTION Ontario Inst. for Studies in Education, Toronto.
PUB DATE Nov 72
NOTE 29p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Biology; Course Content; *Course Evaluation; Curriculum Development; *Educational Research; Evaluation; Science Education; *Secondary School Science
IDENTIFIERS *Patterns of Enquiry Project; Research Reports

ABSTRACT

This paper constitutes an analysis of "Honey Bee Communication: An Enquiry into Two Concepts of Animal Behavior," a unit of classroom discussion modules developed by the Patterns of Enquiry Project at the Ontario Institute for Studies in Education. The conceptual framework of the analysis consists of four major items: (1) descriptive characteristics, (2) theoretical orientation, (3) instructional orientation, and (4) comparison and evaluation. Various sections of the unit are analyzed, with particular reference to the goals and orientation of the unit, the structure and format of the textual materials, and suggested ways of using the unit. The textual analysis is directed toward the practical aspects of implementing an enquiry unit. In addition brief considerations concerning the philosophical basis of this approach are made. (Author/JR)

FILMED FROM BEST AVAILABLE COPY

ED 080319

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

PATTERNS OF ENQUIRY: TEXTUAL ANALYSIS OF A CLASSROOM DISCUSSION UNIT ON BEE FEEDING BEHAVIOUR[1]

Richard W. Binns

November 1972

Patterns of Enquiry Project

The Ontario Institute for Studies in Education

SE 016 263

CONTENTS

INTRODUCTION..... 1

I. DESCRIPTIVE CHARACTERISTICS..... 2

1. Instructional Media
2. Course Content

II. THEORETICAL ORIENTATION..... 7

1. Rationale
2. Objectives

III. INSTRUCTIONAL ORIENTATION..... 11

1. Instructional Theory
2. Elements of Instructional Theory

IV. COMPARISON AND EVALUATION..... 14

1. Philosophical Stance
2. Suitability for Intended Student Population
3. Comparison with Other Curricula

OUTCOMES..... 19

BIBLIOGRAPHY AND COLLECTED FOOTNOTES..... 20

APPENDIX..... 21

Figure 1 - Teacher's Edition Pages 24T-24
Figure 2 - Experimental Data
Figure 3 - Bee Communication of Direction
Figure 4 - Bee Dances
Figure 5 - Table of Contents

INTRODUCTION

This paper constitutes an analysis of Honey Bee Communication: An Enquiry into Two Conceptions of Animal Behavior[2], a unit of classroom discussion modules developed by the Patterns of Enquiry Project, the Ontario Institute for Studies in Education. The conceptual framework of the analysis consists of four major items (descriptive characteristics, theoretical orientation, instructional orientation, comparison and evaluation) and appropriate sub-items. In this study, an attempt is made to determine the significance of certain factors which might aid in the prediction of curricular outcomes of the unit.

I. DESCRIPTIVE CHARACTERISTICS

1. Instructional Media

The Honey Bee Communication unit consists of two books - a student edition and a teacher edition. The student edition is printed on the right hand page, and the left hand page is blank. The page is divided vertically, in half, so that the left half contains the textual content. A distinguishing characteristic of this content is the extensive use made of excerpts taken from original research reports. The original quotations are linked together by connecting commentary. The right half contains a variety of instructional information and directions, including additional information, questions and explanatory comments. The teacher edition contains the full student edition plus the teacher's introduction and the left hand page divided vertically, in half. The left half contains tentative answers to the students' questions and the right half of the teacher page contains a running analysis of the original quotations (Figure 1). Both editions also contain tables, figures, and photographs keyed to specific sections of the text (Figures 2, 3, 4).

The teacher's introduction consists of the following six sections: Organization of the Unit, Goals of the Unit, Classroom Discussion, Purposes of the Guide, Orientation of the Unit, and Suggested Ways of Using the Unit. The students' introduction deals explicitly with two themes, knowledge and enquiry.

Consistent with the purpose of the material as a discussion unit, the authors have stressed the textual account and left the development of appropriate laboratory activities for the teacher. Field trips, film strips, slides, etc. are not obligatory to the teaching of the unit and are left to the discretion of the teacher for use as supplementary aids. No special classroom facilities are required and the suggested time period for classroom use is 3-4 weeks.

2. Course Content

The Honey Bee Communication unit was designed for use in grades 9-13 in any high school biology course or as a segment of a general science course. The content is divided into three parts (Figure 5). The first part, consisting of sections I and II, presents the original writings of Karl von Frisch and exemplifies his conception of bee dances as a language for locating food.

In section I the student is introduced to von Frisch's initial problem concerning bee dances and feeding habits. This problem is two-fold, namely: How do bees communicate? and Do bees have a language? Various environmental and bee-specific components of the problem are identified. Reports of experiments to test various hypotheses are presented and using the textual questions the student is invited to "make sense" of the logic of each investigation and its resulting outcomes. Using the original writings as a source of data, the student is requested to collect evidence for an argument. This evidence involves identifying, interpreting and assessing various aspects of von Frisch's enquiries. For example, question two involves the identification of an hypothesis, an interpretation of its relationship to von Frisch's conception and an assessment of his testing procedures. Reports of experiments to test the following hypotheses are presented in section I:

- that the round dance is a symbol communicating a source of nectar and the waggle dance is a symbol communicating a source of pollen (Figure 4).

- that bee dances communicate data about the distance of a food source from the hive.

- that round and waggle dances have meaning in terms of differing distances of the food source from the hive (Figure 2).

Von Frisch interprets his findings resulting in claims that characteristics of foraging bee dances communicate various aspects of distance information to recruiter bees. Through the questioning procedure of the unit, provision

is made for the student to understand the claim, the methods by which it was derived and the tentative nature or warrantability of the claim.

Section II introduces the student to further enquiries of von Frisch concerning the nature of bee communication. The hypotheses being tested are as follows:

- that bees use olfaction to locate food - bees empty their scent organs in flight to provide a scent-path for recruits.

- that bees receive direction as well as distance information from the dance - the direction of the straight run of the waggle dance, determined by orientation to the sun, communicates the direction of a food source (Figure 3).

Emphasis is placed upon student understanding of the effect of guiding conceptions on experimental design, the nature of assumptions and the reliability of knowledge claims. Von Frisch concluded that bees communicate the direction of food sources from the hive in relation to the sun and that olfaction is not a guide to direction at great distances.

The second part of the unit (sections III and IV) presents the original writings of Adrian Wenner and Dennis Johnson. These enquiries demonstrate an alternative conception of bee dances as an unused source of information about food location.

In section III, the student is introduced to Wenner's critical examination of von Frisch's conception of bee behavior. The major criticism was directed toward the effect von Frisch's conception had upon his experimental design. Wenner suggested that the design of the previous experiments excluded the degree to which olfaction could play an important role. He redesigned the experiment, tested von Frisch's distance hypothesis, and his outcomes confirmed it. However, three further experiments with design modifications produced outcomes contrary to the "language" hypothesis. Thus, while not entirely rejecting von Frisch's conception, Wenner concluded that the experiment from which evidence was taken to support the dance "language" hypothesis was inadequately designed. In this section, the student investigates the challenges made upon a guiding conception and its effect upon experimental outcomes. The nature of "controls" and "artifacts" in

experimentation, the revisionary nature of scientific outcomes, the partial interpretation of data, and the generation of new questions from investigations are the primary aspects of scientific enquiry treated.

Section IV introduces the student to Johnson's critical examination of von Frisch's conception of bee behavior as innately patterned. At the outset, the reasons for Johnson's criticisms and indications of his guiding conception are sought. A description of an experiment designed to disprove the "language" hypothesis follows and provision is made for comparisons with von Frisch's and Wenner's experiments. Reports of experiments to test the hypothesis that conditioned responses (such as odor) play an important role in locating food sources are presented and the student is asked to assess Johnson's experimental design, data collection and data interpretation. Johnson concludes his enquiry by claiming that the dance patterns do contain precise information but that bees fail to use this information with the same precision in locating food and that conditioned responses such as local odor clues play an important role. The end of this section provides for student assessment of the adequacy of alternative guiding conceptions.

The third part (sections V, VI, VII) of the unit consists of a comparison of the alternative conceptions of bee behavior. Using research reports excerpted from a scientific journal, the authors have juxtaposed this material such that the nature of debate within the scientific community is presented to the student.

Section V contains von Frisch's defence of his dance language conception. In the writings, he responds to the criticisms of Wenner and Johnson by criticising the design of their experiments and defending his own. He describes specific experimental techniques (eg. Wenner's method of training bees) which he claims resulted in errors of interpretation. Furthermore, he argues that his experiments were properly controlled in spite of the criticisms of his opponents and uses some of Wenner's data as support of the dance language hypothesis. The student is requested to assess the evidence cited and the form of his argument.

In section VI, the original writings consist of a series of excerpts taken from a paper in which Wenner and Johnson collaborated to defend their

olfaction conception. Using more detail, they outlined their conception of how bees locate food sources. Distinct differences between the way they viewed the phenomena (as a "dynamic system") and von Frisch's conception are expressed. The student is requested to search the report for terms indicating the different conceptions and to formulate an argument concerning the adequacy of these diverse points of view. The function of scientific debate and how it contributes to enquiry is demonstrated. For example, in this section, the disagreement appears to be founded basically upon the differing guiding conceptions and resulting interpretations; however, the specific variations accrue from a question of adequately "controlling" within the experimental design. Wenner and Johnson argue that von Frisch's statement of the problem, design of experiment, collection and interpretation of data are primarily influenced by his guiding conception. Student investigation into the role of guiding conceptions and their assumptions is emphasized.

Section VII introduces the student to Wenner's and Johnson's test of the competing conceptions. Through a report of their investigations, they attempt to disprove rather than confirm an hypothesis, test the assumptions underlying guiding conceptions, and thereby contrast the two hypotheses. The experimental procedures and collected data are reported and the student is requested to assess the adequacy of its interpretation and resulting knowledge claims. The researchers claim that the experimental outcomes supported the olfaction hypothesis but admit that there is a correlation between the dance manoeuvre and distance and direction travelled by foragers. Having read much of the evidence presented by the major protagonists involved in the study of bee behavior, the student is invited to formulate his own conceptions and support it with experimental evidence.

An illustrated appendix presents some initial data and the experimental apparatus one might use to investigate bee behaviour from another point of view. It involves an enquiry into the role of bee sounds as a possible means of communication. No reports of experimentation are presented and it provides a starting point for student enquiry into the problem itself.

II. THEORETICAL ORIENTATION

1. Rationale

There are no explicit statements in the Honey Bee Communication unit which assert the educational functions intended through use of these materials. Elsewhere, however, the project director has elaborated on the curricular perspective of these modules[3]. Primary emphasis is placed upon a liberal education in the disciplines of science as opposed to but not the total exclusion of other kinds of education (eg. technical, professional, specialist, etc.). Connelly claims that a liberal education in biology can function so as to contribute to increased *freedom and power with respect to biology* if that *experience* [is] *structured according to principles of enquiry*[4]. He argues that the curricular significance of this power may be realized if biological knowledge is viewed in terms of its form and matter.

> *Its form is given by the logical patterns used in enquiry; its matter is given by the facts, hypotheses, and theories that make up the edifice of biologic knowledge. Patterns of enquiry are restricted in number and represent the effectively different ways of viewing biologic subject matter; on the other hand, the facts, hypotheses, and theories are manifold, and they change or are subsumed as new, more powerful knowledge is generated. Patterns of enquiry exhibit stability and are the basis for a liberal education in biology. They are the curricular perspectives from which students may study the content of biology. In short, the distinction between forms of enquiry and the conceptual and factual matters of biology provides for a curriculum having a stable framework within which to treat the variable content of biology.*[5]

The stable framework is based on principles of enquiry (guiding conceptions) and their respective patterns. The structural components of a pattern of enquiry are represented in the way *problems* are bounded for enquiry, the kind of *data* which pass as evidence, the way *interpretations* of the evidence are made, and the terms in which *knowledge outcomes* are stated. Enquiry, in this view, is a *form of knowledge as experienced* by the scientist and his research accounts are records of the process in which he comes to an understanding about the world. The outcomes of that process are the knowledge claims which are considered as assertions or propositions contingent

upon the components of enquiry. Connelly states that the curricular significance of this philosophy resides in the degree to which biology as a form of knowledge experienced by researchers can become a form of knowledge experienced by students.

The content of Honey Bee Communication suggests that the unit reflects this rationale. The use of two competing theories of bee feeding behavior permits the student to examine the components of enquiries and judge the adequacy of their outcomes. This orientation stresses the way in which biology contributes to the social and intellectual activities of the individual student. Such an emphasis could be said to reflect the aims of a liberal education[6].

2. *Objectives*

The teacher's edition specifies that this unit contributes to four goals of science education. The potential for achieving these objectives can be determined by examining the content and by examining its mode of instruction. The latter will be discussed in another section of this paper.

Goal 1. An understanding of the major theories of honey bee communication associated with their search for nectar.

The content of Honey Bee Communication presents the major theories of bee feeding behavior by means of the original enquiries of von Frisch, Wenner and Johnson. The patterns of enquiry which contributed to the formulation of these theories are represented in detail.

Goal 2. An understanding of the parts (eg. problems, fact, interpretation) of patterns of enquiry and how these patterns contribute to the "status" of knowledge claims.

The structural components of patterns of enquiry can be identified in all sections of the unit. The format of the original writings, students' questions, possible answers, and analyses contribute to their identification. For example, the following pattern of enquiry is located in section I:

Table 1. von Frisch's Pattern of Enquiry

1. Guiding Conception	His conception is that bees communicate by dancing to recruit food-gatherers and thus balance the number of foragers with the amount of food available.

2. Problem	How do bees communicate? Do bees have a language?
3. Data	Data collected include the geometrical movements of bees which have returned to the hive and the number of foraging newcomers which subsequently appear at a distant feeding place.
4. Interpretation	The distance of the feeding place is indicated by the "waggle run frequency" of bee dances.
5. Knowledge Outcome	He claims that bees do have a language - the symbols of which are reflected in components of the dance.

According to the teacher's introduction, understanding the status of a knowledge claim requires a determination of its validity and reliability. The validity of a claim refers to its significance in explaining biological phenomena. Reliability refers to its accuracy in accounting for phenomena. The unit makes provision for such determinations by the extensive use of the original writings of honey bee researchers. For example, von Frisch's claim that bees communicate distance information by means of a dance "language" is valid since, if it is correct, it helps to explain their behaviour. However, the reliability of the claim is low since Wenner and Johnson present other legitimate interpretations of the data.

Goal 3. The reading skills and habits of mind that allow a student to recover the meaning of knowledge claims.

In this unit, the use of original research writings provides for the recovery of meaning of biological knowledge independent of a curriculum writer. The student is freed from the constraints of interpretation by a textbook author and with a grasp of the conceptual framework of enquiry the student could discover meaning independent of the teacher.

Goal 4. The evaluative skills and habits of mind that allow a student to assess the status of knowledge claims.

Honey Bee Communication presents alternative patterns of enquiry which produce diverse knowledge outcomes. Given that a student understands how each pattern yielded its interpretations, the unit provides for the contrasting of enquiries for assessment of logical consistency, phenomena-concept

correspondence, postulational outcomes, etc. Part three, containing the criticisms and defences of the enquirers is a case in point. The following questions (from section VII) solicit the use of these skills: *Upon what assumption is this statement based? What conception of bee feeding behavior was used as a basis for generating these experimental procedures? Which predictions are supported by the data and which are not?*

Consistent with his view of organizing curriculum materials with respect to forms of enquiry, Connelly asserts that the latter three goals reflect elements of the power of these principles in the liberal education of an individual. In general, the content of the unit and its objectives are consistent with the rationale.

III INSTRUCTIONAL ORIENTATION

1. Instructional Theory

The teaching strategy intended for instruction using this unit is described in the teacher's introduction as *Enquiry into Enquiry*. Connelly describes some principles of this theory of instruction as follows:

> *While the materials for an enquiry instructional mode reflect debate within the field, enquiry instruction generates debate within the classroom. Classroom debate centers on the anatomy of a pattern of enquiry and its functions in the curricular recovery of meaning of knowledge claims. For instance, depending on what parts of the paper are chosen as evidence, there may be several answers to the simple question "What is the problem under investigation." The debate generated in a comparative defence and analysis of each answer in the context of a search for the best, i.e. most adequate, answer constitutes an enquiry into enquiry discussion. Students are asked to build arguments for their positions using evidence from the paper. They are asked to hear the arguments of other students and to compare the adequacy of their arguments for making sense of the pattern of enquiry as a whole. And they are asked, if necessary, to withhold judgment and to let diversity stand pending discussion of the entire pattern of enquiry; its guiding conception, required and collected data, interpretation, statement of outcome, and the role played by the principle and problem area.*

Enquiry into Enquiry is seen as a method of discussion involving the active participation of students toward a search for knowledge and a mastery of skills. It allows for the use of these skills through an engagement in the intellectual activities of thought and communication. As such, the instructional mode contributes to the objectives of the unit and its function in a liberal education.

2. Elements of Instructional Theory

The format of the Honey Bee Communication unit is conducive to an enquiry discussion process. The original writings consist of debate materials, the questions are exemplary of biological enquiry, and the sequence of sections is appropriate to the development of knowledge concerning bee behavior. The way in which student - teacher - materials interactions could occur can be demon-

strated from section II (Figure 1). For example, the teacher could ask, "What hypothesis is von Frisch proposing to test?" The question forms the basis of a *problem* for each student. Other aspects of that problem are: "How can I find out?" How will I know that this is the hypothesis?" "What is an hypothesis?" Etc., etc. By identifying and verbalizing certain phrases in the textual materials, the student *hypothesizes* a solution to the problem. In this case, he may state, "Von Frisch's hypothesis is that bees use olfaction to locate food." Another student, who has looked elsewhere might assert the following, "His hypothesis is that bees receive direction as well as distance information from the dance." Each participant then seeks specific terms, words, or phrases which are *data* relevant to the problem and act as evidence supportive of his hypothesis. Varying *interpretations* of these data could be made during argument requiring a search for further data or a revision of original hypotheses. This argumentative phase of the instructional process reflects the debates which exist within the scientific community about competing theories. The outcomes of such a procedure are the *claims* each student makes regarding what he knows about the problem. Furthermore, this instructional process provides for some degree of understanding of how he acquired that knowledge. Within the discussion group, the outcomes of an argument could terminate as consensus among group members or as informed choices by individuals concerning alternative knowledge claims.

The teacher's introduction describes the role of the teacher in enquiry discussion as critical. Clearly, two prerequisite functions for the teacher would be an understanding and assimilation of a mode of analysis appropriate to biological enquiry and the development of effective techniques of discussion. The project has produced a 16 m.m. film, *Enquiry into Enquiry*, and the teacher's edition of the unit to contribute to these activities. A manual, prepared for teacher education, accompanies the film and provides background information, analysis of the discussion, and topics for teacher discussion.

Within the discussion (according to the teacher's introduction), the teacher's authority is directed toward the *way* arguments are advanced. In

this capacity, he is to indicate the soundness of the argument, the nature of the evidence, the logical connections with the general problem etc. In general, the teacher assists students in building arguments. Transcripts from the filmed class discussion are presented in the manual and techniques of conducting the discussion are analyzed.

As indicated previously, the Honey Bee Communication unit has a format which facilitates a discussion mode. The student questions, textual material to be analysed, analysis, and possible answers are presented as columns on opposing pages (Figure 1). This style would aid the teacher who is naive to this type of instruction. Considering the discussion problem presented by the teacher (above), the following subsequent questions could be used to direct instruction:

> "What evidence from the writings supports your statement?"
> "Compare your evidence with that used by X in his argument."
> "What evidence is there that both arguments are possible solutions to the problem?"

If this type of procedure were used, the teacher could shape and refine the students' arts and skills of recovering meaning and hence contribute to goals three and four.

IV COMPARISON AND EVALUATION

1. Philosophical Stance

Although many of the new secondary school science curricula cite "an understanding of the nature of scientific enquiry" as a major objective, Herron has found that three major curriculum projects (PSSC, CHEM Study, BSCS Blue) contain very limited conceptions of and diverse accounts of enquiry.[8] Having developed a conceptual framework for analyzing accounts of scientific enquiry, he tested it on four *reasonably complete and coherent divergent accounts of scientific enquiry* (those of Dewey, Einstein, Pierce and Whewell) before applying it to the science curricula. His scheme involved the identification of five "commonplaces" of enquiry - Agent, Method, Scientific Data, Scientific Knowledge, Dynamics of Revision - and appropriate subcategories. He found his scheme to be compatible with the variety of conceptions of the "scientist-philosophers" yet very poorly represented in the modern science curricula. These outcomes, coupled with those of a study involving science teachers, led him to conclude that the current *operational effectiveness . . . [of teaching] . . . "science as enquiry" is highly questionable.*

The philosophical stance of a science curriculum may be regarded as the *way* in which it presents a "structure of scientific knowledge." It is the manner in which conceptual knowledge structures are presented which allows one to assess its philosophical position. This unit consistently presents knowledge claims as contingent upon the substantive structures governing the enquiry, the discrimination of data as dependent upon starting points, the diversity of verification and discovery processes, the cognitive biases of enquirers, the nature of debate, and the revisionary aspect of scientific knowledge. In short, it demonstrates substantial elements of Herron's "commonplaces" of enquiry. Furthermore, the unit presents science as student enquiry. Through use of the original research reports and an enquiry mode of instruction, it can provide for student involvement in the

enquiry process. These same elements of enquiry can, thus, become "commonplaces" of instruction. In this respect, the philosophical stance of the unit may become not only a view of enquiry but an experience of it. Connelly asserts that this experience can yield a:

> *. . . second-order knowledge [which] allows for the curricular assessment of the warrantability of a knowledge claim; for an assessment of the grounding relationship of the claim in fact, and for the curricular assessment of the conception and pattern of enquiry that places and gives meaning to the claim.*[9]

An examination of the written material of this unit indicates that it has the potential for achieving this.

2. Suitability for Intended Student Populations

The rationale guiding the development of this modular unit and the broad population for which it is intended suggest that considerable attention be directed toward specific situations in which it is to be used. Furthermore, the way in which it is used with various student groups is an important factor in assessing this dimension. This unit is not intended for a full course of studies nor does it constitute a full semester's work. It could, however, become a substantial portion of a one semester general science course.

The content of the unit represents an in-depth treatment of a topic in animal behavior. For a younger student population, it could provide for a major in-depth portion of a general survey course in biology. For an advanced science course it might constitute one aspect of other similar studies. The reading level is appropriate for a grade ten student, although certain terms in the original writings may require some investigation as to specific usage. The consistent use of such terms throughout the textual material of the unit facilitates the understanding of terms in context.

The sequence of sections is appropriate to the development of knowledge of bee behavior and to the enquiry theme of the unit. Von Frisch's enquiries are presented, then the challenging enquiries of Wenner and Johnson, and finally the subsequent debate. The nature of the student questions is appropriate to this development.

The unit appears most suitable for grades ten to twelve but could be adapted to fit one grade higher or lower.

3. *Comparison With Other Curricula*

Comparison of five popular biology textbooks with Honey Bee Communication yielded the following information concerning the nature of enquiry into bee feeding behavior:

Table II

Text	Guiding Conception	Problem	Data	Interpretation	Knowledge Claims
BSCS Green					
BSCS Blue		*		*	*
BSCS Yellow		*		*	*
Modern Biology					*
Biology		*		*	*
H.B. Communication	*	*	*	*	*

BSCS Green[10] does not deal with bee feeding behavior. *Modern Biology* considers only the knowledge outcomes of von Frisch and treats his enquiry as a discovery of facts. The following statements exemplify the treatment:

> *Evidence indicates that bees communicate with one another through the carrying out of a complicated set of dances. When a worker returns to the hive, she can inform the other workers of the kind and amount of nectar available, how far away it is, and in what direction. To do this, she dances on the vertical surface of the comb.*[11]

No mention of the enquirers, conceptions, problem, data or interpretations are made. According to this account, the outcomes are conclusive discoveries which have achieved the status of "fact." The curricular implication is that such outcomes are "facts to be learned" because they are "facts which are known."

Biology considers primarily the knowledge outcomes of von Frisch and treats his enquiry as a discovery of facts. It appears to consider the bee communication problem as one of continuing discovery. For example, it does not seem to consider the enquiries of Wenner and Johnson as competitive but as complimentary to von Frisch's conception. Consider the following statements:

> *Further experiments clearly revealed the method by which a worker bee can direct others to the source of food. (the waggle dance interpretation is given) . . . Several recent experiments indicate that bees may also use other clues in locating food. Such things as hive odors and food odors may be clues that also help bees orient*

to a food source. . . . Various experiments have confirmed this idea.[12]

This text summarizes the knowledge outcomes of all enquirers in a marginal note of the teacher's edition in a form suggestive of one comprehensive theory which is gradually becoming more completely understood with the contributory outcomes of each investigation.

BSCS Yellow[13] presents a diagramatic illustration of the problem of bee feeding behavior and indicates that Wenner and Johnson produce different outcomes than von Frisch. A number of "open-ended" questions are presented which suggest this to be an important part of enquiry and that the outcomes are somewhat tentative. However, no actual data is provided for the student to make his own interpretation.

BSCS Blue presents, in detail, the distance-direction theory of von Frisch and, to a lesser extent, it outlines Wenner's and Johnson's alternative theory. Consider, for example, the following statements:

If this theory proves correct, bees use the most abstract method of communication of any animal other than man. Some new evidence has appeared, however, that suggests that the dance does not communicate distance or direction to a food source . . . An alternate theory is therefore being formed to explain how the bees locate the food source.[14]

Although this text represents the nature of bee feeding enquiry in a more valid form than the four previously mentioned texts, it concludes with the following statements:

You can see then that doubt still exists about how bees communicate. What caused this doubt to develop? Could different varieties of bees produce different results? What about a difference in the bees' environment? Or a difference in the way the experiments were designed? Were all variables well controlled, for example? Could the same general observations be interpreted differently by different observers? Which theory is right or can they both be right?[15]

But the text provides no original data, no indication that the enquirers' viewed the problem differently, no comparative outlines of the differing experimental designs. How, then, can the student answer such questions? What provision has been made for the student to "see that doubt . . . exists"? What provision have the authors made for the student to know? The curricular outcomes of these questions are not that diversity of knowledge claims can exist because of diverse enquiries. These questions are "open-ended" in the sense that no means for finding answers has been provided.

And finally, consider the following concluding statements of this section in the text:

> *You might ask, "Do bees really communicate?" The answer must be "Yes." Otherwise, their highly organized society and their caste system would be impossible.*[16]

This author would claim that such statements are inadmissable in a book which claims to demonstrate the nature of scientific enquiry. They are interpretations devoid of factual data and, in a curricular sense, restrict student freedom with respect to these ideas. Such statements provide inaccurate "second-order knowledge" about the nature of scientific enquiry.

Examination of these various textual accounts indicates that Honey Bee Communication gives the most adequate account of bee feeding behaviour as it is currently known and the most appropriate account of how it is known.

OUTCOMES

The data for this analysis has been obtained from the Honey Bee Communication unit materials and the additional sources cited. The conceptual scheme provided a useful means for description and evaluation.

The unit presents an in-depth treatment of biological knowledge concerning bee feeding behavior and the nature of the enquiries generating that knowledge. The content of the materials and the stated objectives are consistent with the rationale of the project. The potential for achieving the objectives depends, in part, upon the use of an enquiry discussion as instructional mode. The materials contribute to such a teaching strategy and to the philosophical stance of the project. The unit appears most suitable for grades ten to twelve. In contrast to five popular biology textbooks, Honey Bee Communication is most adequate and appropriate for the content considered.

Bibliography and Collected Footnotes

1. This paper was presented at the Science Teachers' Association of Ontario Conference (Toronto, November 4/72) and at the National Science Teachers' Association Convention (Detroit, April 2/73).

2. Palmer, W. & Dienes, B. (principal writers)) Honey Bee Communication: An Enquiry into Two Conceptions of Animal Behavior (1972), a unit of classroom discussion modules developed by the Patterns of Enquiry Project F.M. Connelly (director), Department of Curriculum, The Ontario Institute for Studies in Education.

3. Connelly, F.M. "Liberal Education in Biology: An Enquiry Perspective," The American Biology Teacher, Vol. 34, No. 7 (1972), pp. 385-388, 391.

4. IBID. p. 386.

5. IBID. p. 387

6. Schwab outlines the characteristics of science teaching and its relationship to the aims of a liberal education in the following publication: "The teaching of Science as Enquiry," The Teaching of Science, J.J. Schwab and P.F. Brandwein, Harvard University Press (1962), pp. 3-103.

7. Connelly, F.M. "Patterns of Enquiry and Conceptual Knowledge Structures in the Curriculum," Unpublished Paper (1971), The Ontario Institute for Studies in Education, Toronto, p. 19.

8. Herron, M.D. "The Nature of Scientific Enquiry," School Review (1971), pp. 170-212.

9. Connelly, F.M. op. cit (1971) p. 4.

10. BSCS Green Version. High School Biology (2nd Ed.) (1968), Rand McNally Co., Boulder, Colorado.

11. Otto, J.H. & Towle, A. Modern Biology (1969)
Holt, Rinehart & Winston, New York. pp. 449-450.

12. Smallwood, W.L. & Green, E.R. Biology (1968)
Silver Burdette Co., New Jersey. pp. 636-637.

13. BSCS Yellow Version. Biological Science: An Inquiry into Life (2nd Ed.) (1968) Harcourt, Brace & World, Inc., N.Y. pp. 656-657.

14. BSCS Blue Version. Biological Science: Molecules to Man (2nd Ed.) (1968) Houghton Mifflin Co., Boston, p. 714.

15. Ibid., p. 714.

16. Ibid., p. 714.

APPENDIX

Answers to Questions

1. He is actually proposing to test two hypotheses:
   (a) The null hypothesis (i.e., the one that he expects to disprove) is that bees use olfaction to locate food.
   (b) His hypothesis is that bees receive direction as well as distance information from the dance.
2. He added more observation posts in different directions

Analysis

1.0 Von Frisch continued to consider both language and olfaction hypotheses.

1.1 In order to test these competing hypotheses, he set up additional observation posts in different directions from the hive.

1.11 He found that most recruits went to the observation post (scented dish) most proximate to the feeding place of the trained foragers.

Figure 1 - Teachers

Section II: WHICH DO BEES USE TO LOCATE FOO
LANGUAGE OR OLFACTION? VON FRI
'AN EXPERIMENTS'[1]

1.0 *The question whether the newcomers are receiving information about the distance of feeding place by the dancee or whether they guided into the neighbourhood of the collect by means of their scent organ, was determine experiments now to be discussed.* 8 *I thought observation posts at the same distance as th place, but in a different direction, would s whether bees knew in which direction they ha search or whether they merely followed their*

1.1 *The arrangement of the experiment* 8 *rema before, but we added further observation pos the 10th of August 1944, a group of seven ma bees of a Krainer colony at B (in a Zander h collected at the feeding place F at a distan 150 m. The base of the dish was scented wit drops of peppermint oil. A peppermint scent was placed in the grass at four observation whose position is shown in Fig. 9. In the during which we fed the numbered bees with 1.11 molar solution, 106 newcomers arrived a killed. During the same hour and the follow hour 30 bees arrived at the observation pos*

[1]von Frisch, Dances of Honey Bees, 19-31.

Figure 1 - Teachers Edition Pages 24T - 24

Section II: WHICH DO BEES USE TO LOCATE FOOD: LANGUAGE OR OLFACTION? VON FRISCH'S FAN EXPERIMENTS[1]

1.0 The question whether the newcomers are really receiving information about the distance of the feeding place by the dances or whether they are only guided into the neighbourhood of the collecting place by means of their scent organ, was determined by experiments now to be discussed. ¶ *I thought that observation posts at the same distance as the feeding place, but in a different direction, would show whether bees knew in which direction they had to search or whether they merely followed their noses.*

1.1 The arrangement of the experiment ¶ *remained as before, but we added further observation posts. On the 10th of August 1944, a group of seven numbered bees of a Krainer colony at B (in a Zander hive) collected at the feeding place F at a distance of 180 m. The base of the dish was scented with a few drops of peppermint oil. A peppermint scented plate was placed in the grass at four observation posts whose position is shown in Fig. 9. In the one hour during which we fed the numbered bees with a 2 1.11 molar solution, 100 newcomers arrived and were killed. During the same hour and the following half-hour 20 bees arrived at the observation post 18 m.*

[1]von Frisch, Dances of Honey Bees, 19-31.

Q1. What hypothesis is von Frisch proposing to test?

Q2. How has he altered his experimental design?

Figure 2 - Experimental Data

TABLE 3

Experiment No.	Date	Distance of feeding place from hive	Average No. of waggle runs per 15 secs.	No. of individual observations on which the average is based
7	8.6.45	100 m.	10,9	9
8 and 9	11 and 12.6	150 m.	8,7	12
10	12.6	200 m.	8,3	16
11	14.6	300 m.	7,6	29
13	15.6	400 m.	6,6	24
16	16.6	500 m.	6,2	31
17, 18	16.6	600 m.	5,9	33
19, 20	17 and 18.6	700 m.	5,0	23
21	18.6	850 m.[1]	4,8	34
23	18.6	900 m.	4,7	33
24	19.6	1000 m.	4,5	30
26	19.6	1100 m.	4,5	37
28	21.6	1200 m.	4,2	15
31	21.6	1300 m.	4,3	54
34	22.6	1400 m.	4,1	68
37	23.6	1500 m.	4,0	31

[1] Instead of at 800 m., where there was a swamp.

Figure 3 - Bee Communication of Direction

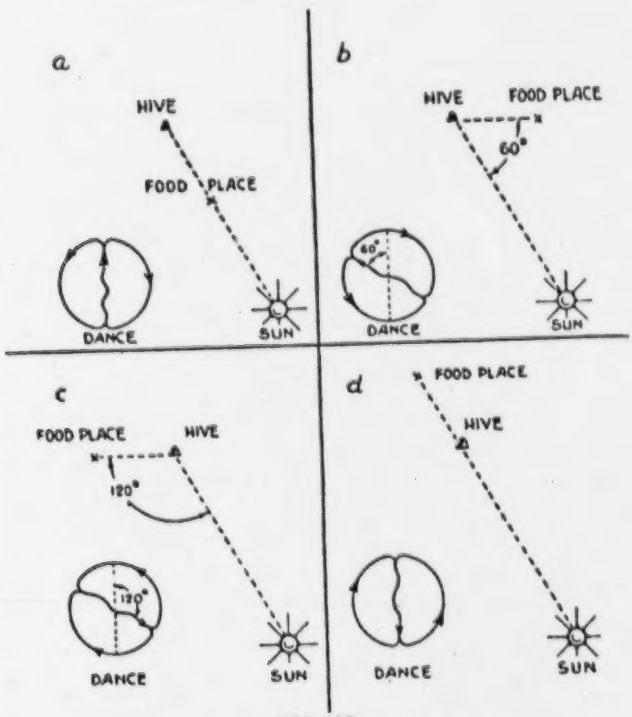
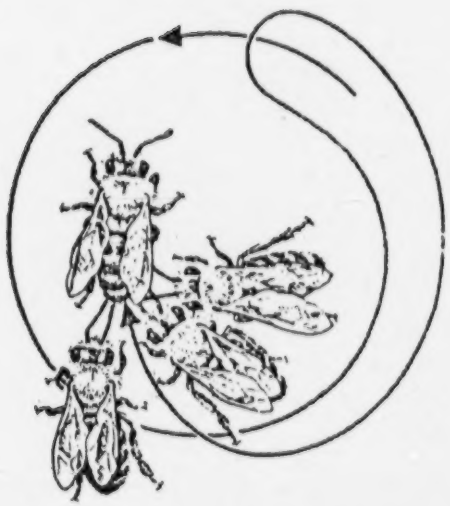


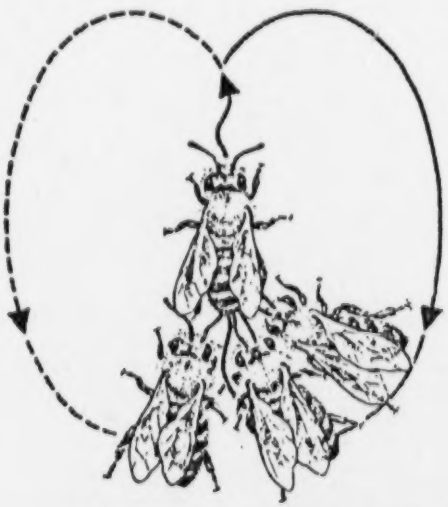
FIG. 17

Four examples of indication of direction. The sun is to the south-east of the hive. The diagram in each lower left hand corner shows schematically the direction of the waggle dance for a given position of the feeding place.

Figure 4 - Bee Dances



ROUND DANCE, performed by moving in alternating circles to the left and to the right, is used by honeybees to indicate the presence of a nectar source near the hive.



WAGGING DANCE indicates distance and direction of a nectar source farther away. Bee moves in a straight line, wagging her abdomen, then returns to her starting point.

Figure 5 - Table of Contents

Contents

Introduction to the Teacher..... v

Introduction to the Student..... 1

1. A Conception of Bee Dances as a Language for Locating Food..... 3

Section I: What is the Language of Bee Communication?
The Work of Karl Von Frisch..... 4

Section II: Which do Bees use to Locate Food: Language or Olfaction?
Von Frisch's Fan Experiments..... 24

2. A Conception of Bee Dances as an Unused Source of Information About Food Location:
Odor as an Alternative Basis..... 36

Section III: Do Bees use the Distance Information Contained in Their Dance Maneuver?
The Critical Enquiries of Adrian Wenner..... 37

Section IV: Do Bees Use the Direction Information Contained in Their Dance Maneuver?
The Critical Enquiries of Dennis Johnson..... 46

3. Defense and Criticism..... 56

Section V: Von Frisch's Defence of his Dance Language Conception.
The Relationship Between Language and Odor Clues in Food Location..... 57

Section VI: Wenner's and Johnson's Defence of Their Olfaction Conception.
Are Bees Misled by Odor..... 70

Section VII: A Test of Competing Conceptions.
The Role of Hive Odor in Bee Feeding Behavior..... 79

Appendix Illustrations: Sound..... 89